

CLAIMS

1. A charging equipment for a secondary battery, comprising:

a voltage increment means for incrementing check voltage by a preset pitch of voltage from lowest check voltage lower than rated equilibrium voltage at full charge of any secondary battery of all kinds to be charged;

a charge voltage supply means for supplying special charging voltage that is higher than rated equilibrium voltage at full charge of any secondary battery of all kinds to be charged but does not enter an irreversible chemical reaction region;

a switch means for switching voltage applied to the secondary battery between a voltage selected from the group consisting of the special charging voltages supplied by the charge voltage supply means, and the check voltage supplied by the voltage increment means;

a current detection means for detecting electric current flowing through the secondary battery during application of the check voltage to the secondary battery;

a first judging means for judging whether electric current detected by the current detection means is smaller than or as large as a preset standard electric current for judging; and

a second judging means for judging whether a time required for a period from the last affirmative judgment judged by the first judging means to the present affirmative judgment judged by the first judging means is larger than r (r is a real number not smaller than 1) times as large as a time required for a period from the before-last affirmative judgment judged by the first judging means to the last affirmative judgment judged by the first judging means,

wherein charge of the secondary battery is controlled according to first to seventh steps as follows:

the first step, where the lowest check voltage is applied to the secondary battery for a short time, and the current detection means detects electric current flowing through the secondary battery during the short time;

the second step, where the first judging means judges the detected electric current so as to execute a command selected from the group consisting of passing to the third step when the electric current is larger than the standard electric current for judging, and jumping to the fourth step when the electric current is smaller than or as large as the standard electric current for judging;

the third step, where the switch means switches the applied voltage to the special charging voltage, the special charging voltage is applied to the secondary battery for a predetermined time, and then the switch means switches the applied voltage to the lowest check voltage, and a step returns to the first step;

the fourth step, where the voltage increment means sets renewed check voltage made by the present check voltage plus the pitch of voltage;

the fifth step, where the switch means switches the applied voltage to the special charging voltage, the special charging voltage is applied to the secondary battery for a predetermined time, and then the switch means switches the applied voltage to the renewed check voltage, the renewed check voltage is applied to the secondary battery for a short time, and the current detection means detects electric current flowing through the secondary battery during the application of the renewed check voltage to the secondary battery;

the sixth step, where the first judging means judges the detected electric current so as to execute a command selected from the group consisting of returning to the fifth step when the electric current is larger than the standard electric current for judging, and passing to the seventh step when the electric current is smaller than or as large as the standard electric current for judging; and

the seventh step, where the second judging means judges the time required for the period from the last affirmative judgment judged by the first judging means to the present affirmative judgment judged by the first judging means so as to execute a command selected from the group consisting of returning to the fourth step when the time required for the period from the last affirmative judgment judged by the first judging means to the present affirmative judgment judged by the first judging means is not larger than r times as large as the time required for the period from the before-last affirmative judgment judged by the first judging means to the last affirmative judgment judged by the first judging means, and outputs a signal to stop charging when the time required for the period from the last affirmative judgment judged by the first judging means to the present affirmative judgment judged by the first judging means is larger than r times as large as the time required for the period from the before-last affirmative judgment judged by the first judging means to the last affirmative judgment judged by the first judging means.

2. The charging equipment for a secondary battery according to claim 1, wherein, when the signal to stop charging is outputted at the seventh step, the switch means switches the applied voltage to the special charging voltage, the special charging voltage is applied to the secondary battery for a second predetermined time, and then charge of the secondary battery is finished.

3. The charging equipment for a secondary battery according to claim 1 or 2, wherein the required time is measured by counting the number of switching of the applied voltage to the check voltage by the switch means.

4. The charging equipment for a secondary battery according to any of claims 1 to 3, the voltage increment means comprising:

a microcomputer for outputting a pulse wave of pulse width $c \cdot w$ from one predetermined output terminal on the premise that w is a time having a length of one of n (n is an integer not smaller than 2) equal divisional parts of one cycle of the pulse wave, and c ($c=1,2,\dots,n$) is a variable;

a supremum and infimum voltage setting circuit for inverting the maximum and the minimum of amplitude of the pulse wave outputted from the output terminal to each other, and setting the maximum of amplitude of the inverted pulse wave as supremum voltage and the minimum of amplitude of the inverted pulse wave as infimum voltage; and

an arithmetic circuit for averaging the voltage of the pulse wave outputted from the supremum and infimum voltage setting circuit, and outputting a value of voltage made by base voltage minus the just averaged voltage,

wherein the valuable c in the microcomputer is incremented, so that the value of voltage outputted from the arithmetic circuit is incremented by the pitch of voltage.

5. The charging equipment for a secondary battery according to any of claims 1 to 3, the voltage increment means comprising:

a microcomputer for outputting a pulse wave of pulse width $c \cdot w$ from one predetermined output terminal on the premise that w is a time having a length of one of n (n is an integer not smaller than 2) equal divisional parts of one cycle of the pulse wave, and c ($c=1,2,\dots,n$) is a variable;

a supremum and infimum voltage setting circuit for setting the maximum of amplitude of the pulse wave outputted from the output terminal as supremum voltage and the minimum of amplitude of the pulse wave as infimum voltage; and

an arithmetic circuit for averaging the voltage of the pulse wave outputted from the supremum and infimum voltage setting circuit, and

outputting a value of voltage made by base voltage plus the just averaged voltage,

wherein the valuable c in the microcomputer is incremented, so that the value of voltage outputted from the arithmetic circuit is incremented by the pitch of voltage.

6. The charging equipment for a secondary battery according to any of claims 1 to 3, the voltage increment means comprising:

a microcomputer for outputting a pulse wave of pulse width $c \cdot w$ from one predetermined output terminal on the premise that w is a time having a length of one of n (n is an integer not smaller than 2) equal divisional parts of one cycle of the pulse wave, and c ($c=1,2,\dots,n$) is a variable;

a supremum and infimum voltage setting circuit for inverting the maximum and the minimum of amplitude of the pulse wave outputted from the output terminal to each other, and setting the maximum of amplitude of the inverted pulse wave as supremum voltage and the minimum of amplitude of the inverted pulse wave as infimum voltage; and

an arithmetic circuit for averaging the voltage of the pulse wave outputted from the supremum and infimum voltage setting circuit, and outputting a value of voltage made by base voltage plus the just averaged voltage,

wherein the valuable c in the microcomputer is decremented, so that the value of voltage outputted from the arithmetic circuit is incremented by the pitch of voltage.

7. The charging equipment for a secondary battery according to any of claims 1 to 3, the voltage increment means comprising:

a microcomputer for outputting a pulse wave of pulse width $c \cdot w$ from one predetermined output terminal on the premise that w is a time having a

length of one of n (n is an integer not smaller than 2) equal divisional parts of one cycle of the pulse wave, and c ($c=1,2,\cdots,n$) is a variable;

a supremum and infimum voltage setting circuit for setting the maximum of amplitude of the pulse wave outputted from the output terminal as supremum voltage and the minimum of amplitude of the pulse wave as infimum voltage; and

an arithmetic circuit for averaging the voltage of the pulse wave outputted from the supremum and infimum voltage setting circuit, and outputting a value of voltage made by base voltage minus the just averaged voltage,

wherein the valuable c in the microcomputer is decremented, so that the value of voltage outputted from the arithmetic circuit is incremented by the pitch of voltage.